OUTER-LOOP POWER CONTROL FOR WIRELESS COMMUNICATION SYSTEMS

Claim of Priority under 35 U.S.C. §119

[0001] The present Application for Patent claims priority to Provisional Application No. 60/448,269 entitled "Reverse Link Data Communication" filed February 18, 2003, Provisional Application No. 60/452,790 entitled "Method and Apparatus for a Reverse Link Communication in a Communication System" filed March 6, 2003 and Provisional Application No. 60/470,770 entitled "Outer-Loop Power Control for Rel. D" filed May 14, 2003, and all of which are assigned to the assignee hereof and hereby expressly incorporated by reference herein.

BACKGROUND

Field

[0002] The invention relates generally to the field of telecommunications, and more specifically to mechanisms for detecting and evaluating packets and frame transmissions in a wireless communication system having multiple channels with varying channel qualities.

Background

[0003] Wireless communication technologies are rapidly advancing, and wireless communication systems are utilized to provide a larger and larger portion of the communications capacity that is currently available to users. This is true despite the additional technological impediments that are faced in implementing a wireless communication system, as compared to a wireline system. For instance, wireless communication systems must deal with issues relating to data transmission between a base station and its mobile stations in order to maximize the performance of the system, whereas a wireline system does not.

[0004] One type of wireless communication system comprises a cellular CDMA2000 (code division multiple access) system which is configured to support voice and data communications. This system may have multiple base stations which communicate via wireless channels with multiple mobile stations. (The base stations are also typically coupled via wireline networks to various other systems, such as a public switched

telephone network.) Each base station communicates with a set of mobile stations that are within a sector corresponding to the base station. This base station is responsible for detecting errors in transmissions from the mobile station in order to properly demodulate and decode the signal from the mobile stations in addition to controlling power in communications between the base station and the mobile stations in order to minimize interference and maximize throughput, as well as enabling the mobile stations to conserve energy and thereby extend the amount of time during which they can be used.

[0005] Typically, a cyclical redundancy check (CRC) is utilized to detect errors in transmissions from the mobile stations. Ideally, transmissions are divided into predetermined lengths and divided by a fixed divisor. The remainder number from this division operation is then appended onto the transmission by the mobile station. Upon receiving the transmission, the base station recalculates the remainder and compares it to the received remainder. If the two remainders do not match, the base station has detected an error in the transmission.

[0006] This method for error detection, however, may not be feasible for certain types of transmission channels. Burst oriented data transmission channels may have a corresponding rate indicator channel which signals a base station of the transmit format of the burst oriented channel and drives the power control loop. While a CRC may allow error detection in data transmissions, in systems having channels which transmit sporadically and are burst oriented the overhead for utilizing a CRC on their corresponding rate indicator channel may be too high. In most cases, a CRC requires 8 to 10 bits to be appended to each data transmission, however, on a rate indicator channel a transmission itself may only consist of a few bits at a time. The transmission of these added CRC bits increases transmission power significantly. This is problematic, however, as the base station still requires high probability identification of good and bad frames on this rate indicator channel in order to detect the transmit format of these enhanced channels and for adjustment of the power control loop.

[0007] There is therefore a need in the art for systems and methods which allow identification of packets on a rate indicator channel, and the high probability identification of good and bad frames on the rate indicator channel and the corresponding spontaneous data transmission channel.

SUMMARY

[0008] Embodiments disclosed herein address the above stated needs by providing systems and methods which allow reliable detection and evaluation of packets and transmission frames with low overhead.

[0009] Some wireless communication systems have a burst oriented channel and an accompanying rate indicator channel. Rather than performing error detection based upon a system carrying an unreasonable overhead for CRC, it is desirable to provide low overhead, high probability, identification of bad frames within a channel.

[0010] Various embodiments of the present invention attempt to improve the detection of packets and evaluation of frames in systems having a spontaneous, burst oriented data transmission channel and an accompanying rate indicator channel. More specifically, the presence of packets on a rate indicator channel is analyzed, and based upon the presence of packets on this channel, and the type of packets present, the validity of one or more frames may be determined. The presence of data on the corresponding data transmission channel may also be used to confirm this determination.

[0011] One embodiment comprises a method for evaluating packets and frames in a wireless communication system having a burst oriented channel and a corresponding rate indicator channel, comprising decoding the rate indicator channel using a maximum likelihood decoder and detecting the presence of a packet on the rate indicator channel based on a likelihood. In one embodiment, the rate indicator channel is decoded at predetermined intervals. After the detection of a packet, the packet is analyzed to determine whether or not it is valid. If the packet is a zero-rate packet and was expected, energy may be detected on the corresponding burst oriented data channel to make a further determination whether the zero-rate packet is valid. If the packet is not a zero-rate packet, in this embodiment the sub-packet identifier and the payload contained in the packet may be analyzed, and if they contradict expectations, the information in the packet may be used to decode the corresponding burst oriented channel to make a further determination as to whether the current packet or the previous packets are invalid. However, if no packet is detected on the rate indicator channel, and no packet was expected, the burst oriented data channel may be analyzed. In this manner a packet may be detected on the rate indicator channel and the validity of transmission frames determined.

[0012] An alternative embodiment of the invention comprises a wireless communication system comprising a base station and a mobile station coupled to the base station via a wireless communication link, wherein the base station is configured to receive data from the mobile station on a plurality of reverse-link channels on the wireless communication link including a burst oriented channel, and a corresponding rate indicator channel, and wherein the base station is configured to decode the rate indicator channel using a maximum likelihood decoder and determine the presence of a packet on the rate indicator channel based on a likelihood. In one embodiment, the rate indicator channel is decoded at a predetermined interval. After the detection of a packet, the validity of a frame may be determined. If a packet is detected this packet is analyzed. If the packet is a zero-rate packet and was expected, energy may be detected on the corresponding burst oriented data channel to make a further determination of whether the zero-rate packet is valid. If the packet is not a zero-rate packet, the sub-packet identifier and the payload contained in the frame may be analyzed, and if they contradict expectations the information in the packet may be used to decode the corresponding burst oriented channel. However, if no packet is detected on the rate indicator channel, and no packet was expected, the burst oriented data channel may be tested for energy. In this manner a packet may be detected on the rate indicator channel and the validity of transmission frames may be determined.

[0013] Numerous additional embodiments are also possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Various aspects and features of the invention are disclosed by the following detailed description and the references to the accompanying drawings, wherein:

[0015] FIGURE 1 is a diagram illustrating the structure of an exemplary wireless communications system in accordance with one embodiment;

[0016] FIGURE 2 is a functional block diagram illustrating the basic structural components of a wireless transceiver system in accordance with one embodiment;

[0017] FIGURE 3 is a diagram illustrating multiple channels between the mobile station and base station in accordance with one embodiment;

[0018] FIGURE 4 is a diagram illustrating one general embodiment of the present invention to determine the validity of frames on a rate indicator channel and a

corresponding burst oriented data channel via the detection and evaluation of packets on the rate indicator channel; and

[0019] FIGURE 5 is a flow diagram illustrating a method used in conjunction with a rate indicator channel and a corresponding burst oriented data channel to detect packets on the rate indicator channel and evaluate the validity of frames on the channels.

[0020] While the invention is subject to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and the accompanying detailed description. It should be understood, however, that the drawings and detailed description are not intended to limit the invention to the particular embodiments which are described.

DETAILED DESCRIPTION

[0021] One or more embodiments of the invention are described below. It should be noted that these and any other embodiments described below are exemplary and are intended to be illustrative of the invention rather than limiting.

[0022] As described herein, various embodiments of the invention comprise systems and methods for providing packet error detection in a rate indicator channel and its corresponding data transmission channel wherein a high probability of error detection is provided with low overhead.

[0023] A few terms are defined or clarified to aid in understanding the descriptions that follow. A *packet* may be understood in the context of this disclosure as a discreet piece of a message or a series of bits. A *transmission frame (frame)* may be understood as transmissions on one or more channels for a particular segment of time.

[0024] In one embodiment, a wireless communication system provides multiple reverse-link channels for communication of data from a mobile station to a base station. These channels include a burst oriented transmission channel (also referred to herein as a traffic channel) and its corresponding rate indicator channel. In order to detect the presence of packets on the rate indicator channel, the channel is monitored and decoded utilizing a maximum likelihood decoder. Based on the likelihood that a particular packet was received and a comparison of this likelihood to a threshold value, a determination can be made as to whether a packet is present. The maximum likelihood decoder is used because in contrast to conventional channels, no CRC information is provided in packets on the rate indicator channel.

[0025] Based on this detection of packets on the rate indicator channel, the validity of a transmission frame may be evaluated. Additionally, in many cases, the information on the corresponding burst oriented transmission channel is used to help evaluate the validity of the transmission frames. If a zero-rate packet was detected on the rate indicator channel, yet there is enough energy present on the data transmission channel, a bad transmission frame may be declared. Conversely, if a packet detected on the rate indicator channel indicates the presence of information on the data transmission channel, but the data transmission channel cannot be decoded correctly, a bad transmission frame may also be declared.

[0026] Although exemplary embodiments of the systems and methods presented are utilized throughout the present disclosure in the context of a CDMA2000 reverse enhanced supplemental channel (R-ESCH) and its accompanying reverse rate indicator channel (R-RICH), it will be understood by those skilled in the art that embodiments of the present invention may be utilized with other burst oriented communication channels and accompanying rate indicator channels.

[0027] A preferred embodiment of the invention is implemented in a wireless communication system that conforms generally to a release of the CDMA2000 specification. CDMA2000 is a 3rd Generation (3G) wireless communication standard that is based on the IS-95 standard. The CDMA2000 standard has evolved and continues to evolve to continually support new services in a standard 1.25 MHz carrier. The preferred embodiment of the invention is intended to be operable in systems utilizing Release D of the CDMA2000 standard, but other embodiments may be implemented in other Releases of CDMA2000 or in systems that conform to other standards (e.g., W-CDMA). The embodiments described herein should therefore be considered exemplary, rather than limiting.

[0028] Referring to FIGURE 1, a diagram illustrating the structure of an exemplary wireless communications system is shown. As depicted in this figure, system 100 comprises a base station 110 that is configured to communicate with a plurality of mobile stations 120. Mobile stations 120 may, for example, be cellular telephones, personal information managers (PIMs or PDAs), or the like that are configured for wireless communication. It should be noted that these devices need not actually be "mobile," but may simply communicate with base station 110 via a wireless link. Base station 110 transmits data to mobile stations 120 via corresponding forward link (FL)

channels, while mobile stations 120 transmit data to base station 110 via corresponding reverse link (RL) channels.

[0029] It should be noted that, for the purposes of this disclosure, identical items in the figures may be indicated by identical reference numerals followed by a lowercase letter, e.g., 120a, 120b, and so on. The items may be collectively referred to herein simply by the reference numeral.

[0030] Base station 110 is also coupled to a switching station 130 via a wireline link. The link to switching station 130 allows base station 110 to communicate with various other system components, such as a data server 140, a public switched telephone network 150, or the Internet 160. It should be noted that the mobile stations and system components in this figure are exemplary and other systems may comprise other types and other combinations of devices.

[0031] While, in practice, the specific designs of base station 110 and mobile stations 120 may vary significantly, each serves as a wireless transceiver for communicating over the forward and reverse links. Base station 110 and mobile stations 120 therefore have the same general structure. This structure is illustrated in FIGURE 2.

[0032] Referring to FIGURE 2, a functional block diagram illustrating the basic structural components of a wireless transceiver system in accordance with one embodiment is shown. As depicted in this figure, the system comprises a transmit subsystem 222 and a receive subsystem 224, each of which is coupled to an antenna 226. Transmit subsystem 222 and receive subsystem 224 may be collectively referred to as a transceiver subsystem. Transmit subsystem 222 and receive subsystem 224 access the forward and reverse links through antenna 226. Transmit subsystem 222 and receive subsystem 224 are also coupled to processor 228, which is configured to control transmit and receive subsystems 222 and 224. Memory 230 is coupled to processor 228 to provide working space and local storage for the processor. A data source 232 is coupled to processor 228 to provide data for transmission by the system. Data source 232 may, for example, comprise a microphone or an input from a network device. The data is processed by processor 228 and then forwarded to transmit subsystem 222, which transmits the data via antenna 226. Data received by receive subsystem 224 through antenna 226 is forwarded to processor 228 for processing and then to data output 234 for presentation to a user. Data output 234 may comprise such devices as a speaker, a visual display, or an output to a network device.

[0033] Persons of skill in the art of the invention will appreciate that the structure depicted in FIGURE 2 is illustrative and that other embodiments may use alternative configurations. For example, processor 350, which may be a general-purpose microprocessor, a digital signal processor (DSP) or a special-purpose processor, may perform some or all of the functions of other components of the transceiver, or any other processing required by the transceiver. The scope of the claims appended hereto are therefore not limited to the particular configurations described herein.

[0034] Considering the structure of FIGURE 2 as implemented in a mobile station, the components of the system can be viewed as a transceiver subsystem coupled to a processing subsystem, where the transceiver subsystem is responsible for receiving and transmitting data over wireless channel and the processing subsystem is responsible for preparing and providing data to the transceiver subsystem for transmission and receiving and processing data that it gets from the transceiver subsystem. The transceiver subsystem could be considered to include transmit subsystem 222, receive subsystem 224 and antenna 226. The processing subsystem could be considered to include processor 228, memory 230, data source 232 and data output 234.

[0035] As indicated above, the communication link between the base station and the mobile station actually comprises various channels. Referring to FIGURE 3, a diagram illustrating multiple channels between the mobile station and base station is shown. As depicted in the figure, Base station 110 transmits data to mobile station 120 via a set of forward link channels 310. These channels typically include both traffic channels, over which data is transmitted, and control channels, over which control signals are transmitted. Each of the traffic channels generally has one or more control channels associated with it. Forward link channels 310 may include, for example, a Forward Fundamental Channel (F-FCH) that may be used to transmit low-speed data, a Forward Supplemental Channel (F-SCH) that may be used for high-speed, point-to-point communications, or a Forward High-Speed Broadcast Channel (F-HSBCH) that may be used to broadcast messages to multiple recipients. The channels may also include a Forward Dedicated Control Channel (F-DCCH), a forward broadcast control channel (F-BCCH) or a Forward Paging Channel (F-PCH) that may be used to transmit control information relating to the traffic channels or to other aspects of the operation of the system.

[0036] Mobile station 120 transmits data to base station 110 via a set of reverse link channels 320. Again, these channels typically include both traffic channels and control channels. Mobile station 120 may transmit data back to the base station over such channels as a reverse access channel (R-ACH), an extended reverse access channel (R-EACH), a reverse request channel (R-REQCH), a reverse enhanced supplemental channel (R-ESCH), a reverse dedicated control channel (R-DCCH), a reverse common control channel (R-CCCH), or a reverse rate indicator channel (R-RICH).

[0037] In many instances, reverse link capacity is interference limited. Base stations allocate available reverse link communication resources to mobile stations for efficient utilization to maximize throughput in accordance with Quality of Service (QoS) requirements for the various mobile stations.

[0038] Maximizing the use of the reverse link communication resources involves several factors. One factor to consider is the mix of scheduled reverse link transmissions from the different mobile stations, each of which may be experiencing varying channel quality at any given time. To increase overall throughput (the aggregate data transmitted by all the mobile stations in the cell), it is desirable for the entire reverse link to be fully utilized whenever there is reverse link data to be sent. To fill the available capacity, some mobile stations may be granted access at the highest rate they can support. Additional mobile stations may be granted access until capacity is reached. In deciding which mobile stations to schedule, the base station may therefore consider the maximum rate each mobile station can support, the efficiency of the transmission from the mobile station, and the amount of data each mobile station has to transmit. A mobile station capable of higher throughput (considering both the data rate supportable by the mobile station and the amount of data the mobile station has to transmit) may be selected instead of an alternate mobile station that cannot currently support the higher throughput.

[0039] Another factor to be considered is the quality of service required by each mobile station. It may be permissible to delay access to a particular mobile station in hopes that the mobile station's channel (or more specifically its supportable throughput) will improve, instead selecting mobile station that can support higher throughput. It may be the case, however, that a sub-optimal mobile station may need to be granted access in order to allow the mobile station to meet minimum quality of service guarantees. Therefore, the data throughput that is actually scheduled may not be the absolute

maximum, but may instead be optimized in light of channel conditions, available mobile station transmit power, quality of service requirements, and similar factors.

[0040] Various scheduling mechanisms may be used to allow a mobile station to transmit data on the reverse link. One class of reverse link transmissions involves a sporadic, burst oriented data transmission channel such as an R-ESCH, and the channel's accompanying rate indicator channel (R-RICH). When the R-ESCH is transmitting data, the R-RICH carries a corresponding non-zero rate packet. This non-zero rate packet on the R-RICH signals the base station as to the transmit format on the corresponding R-ESCH, provides a sub-packet identifier and a payload size, drives the power control loop when necessary and may provide additional pilot energy for demodulation and decoding of the R-ESCH.

[0041] Conversely, when the R-ESCH is not transmitting, the R-RICH transmits a zero-rate packet periodically, usually at a fixed frame boundary such as the boundary of 80ms frames. The rate indicator packet may have a length that is less than the frame length (e.g. 10ms) so that the duty cycle of the R-RICH may be less than 100% when only zero-rate packets are being transmitted.

[0042] A mobile station may move within the area serviced by a base station, changing the power requirements for a data transmission on the R-ESCH. This zero-rate packet is used to provide some information to drive the power control loop and ensure accurate and efficient transmissions. If the power control loop is not maintained, transmissions on the R-ESCH may be erased because of inadequate power, or the mobile station may utilize more power than necessary in transmission, decreasing its energy efficiency.

[0043] Because of the non-continuous nature of transmissions on the R-ESCH and R-RICH, the base station must make a determination when a packet is present on the R-RICH, and if the transmission frames of the R-RICH and its corresponding R-ESCH are valid. Conventionally, there was no need for an R-RICH, as transmission on data channels was more or less continuous and the transmission format of the data channels was known to the base station. In other words, detection and decoding of data frames and control of the power loop could be preformed based essentially on the data transmission channel itself. In the present system, the mobile station can decide whether to transmit on the R-ESCH and at what rate, as long as the data rate on the R-ESCH is not higher than the authorized rate from the base station. Both a data transmission channel (R-ESCH) and a control channel (R-RICH) are involved because of the above

nature of the R-ESCH, and consequently, since transmission on the corresponding R-RICH is not continuous and the transmission format of the data channel is unknown to the base station, there is a need to detect the presence of packets on the R-RICH and the validity of associated transmission frames.

[0044] A flow diagram depicting an overview of methods employed by embodiments of the present invention for determining the validity of a transmission frame is depicted in FIGURE 4. Generally, these methods may be used in conjunction with a spontaneous, burst oriented transmission channel such as an R-ESCH and the data channel's corresponding rate indicator channel such as an R-RICH which may transmit its zero-rate packets on a fixed and specified frame boundary. In one embodiment, an R-RICH is monitored (block 510), and a maximum likelihood decoder is used to determine the presence of packets on the monitored R-RICH (block 520). Based on the presence or absence of packets and the associated conditions the validity of one or more transmission frames on the R-RICH and its corresponding R-ESCH may be determined (block 530).

[0045] Turning now to FIGURE 5, a flow diagram illustrating in more detail the methods employed to detect the presence of packets on a channel and the validity of associated frames is depicted. When monitoring an R-RICH a base station can detect the presence of packets by decoding the R-RICH to generate a likelihood of each possible codeword (block 402) and comparing the likelihood of the most likely codeword with a threshold (block 404), based on this comparison it can be determined initially whether a packet is present on the R-RICH. The packet, or lack thereof, can then be analyzed to determine the validity of transmission frames. In one embodiment, the first step in detecting packets on the R-RICH is to decode the R-RICH at every frame boundary (block 402) such as the boundary of 10 ms frames. Since the R-RICH may utilize a short block code a maximum-likelihood (ML) decoder may be used to identify a most likely codeword (W) and an associated likelihood (L) of the presence of that codeword on the R-RICH. The likelihood (L) of the most likely codeword (W) can then be compared against a threshold (Th) (block 404). If the likelihood (L) of the most likely codeword (W) is greater than some threshold level (L>Th), it may be decided that a packet has been detected on the R-RICH channel. Otherwise, it can be decided that no packet was detected on the R-RICH channel for the frame under analysis. While maximum likelihood decoders are well known in the art and have been implemented in

the past to assign likelihoods to continuous bit streams, it is a novel approach to apply a maximum likelihood detector to determine the presence of packets on a discontinuous transmission channel. In some embodiments of the present invention, the maximum likelihood decoder may be implemented as a bank of correlators.

[0046] Referring again to FIGURE 5, based upon the base station's detection of a packet on the R-RICH, the validity of the transmission for the frame can then be determined. If the likelihood (L) of the most likely codeword (W) is greater than some threshold level (L>Th), it may be determined that a packet is present on the R-RICH (block 404). If a packet is present on the R-RICH, the base station may then analyze the packet and determine if the packet detected on the R-RICH is a zero-rate packet (block 406). If the base station determines that a zero-rate packet is present (block 406) and it was not expecting a zero-rate packet (block 408), for example if a zero-rate packet is detected at a time other than the specified frame boundary, it can be determined that the frame is invalid (block 424). Conversely, if the base station was expecting a zero-rate packet (block 408) a good frame may be declared. In many embodiments, if a zero-rate packet was expected (block 408) the base station may use the corresponding R-ESCH to further evaluate the validity of the frame (block 422). If enough energy is detected on the R-ESCH to determine that there is data present (block 422) this belies the zero-rate packet detected on the R-RICH (block 406), and because of this discrepancy the frame may be declared invalid (block 426). If, however, the energy detected on the corresponding R-RESCH (block 422) is congruent with the zero-rate packet detected (block 406) a good frame may be declared on the R-RICH (block 428).

[0047] If base station detects the presence of a packet (block 404) and it is not a zero-rate packet (block 406) it may analyze the contents of the detected packet (block 410). This analysis (block 410) may be based on the pre-determined timing for synchronous incremental redundancy (SIR), and a pre-defined order of sub-packet identifiers (ID) in transmissions on the R-RICH. In many embodiments, packets on the R-RICH contain a sub-packet ID and a payload. When a packet on the R-ESCH is initially transmitted from mobile station 120 to base station the packet on the R-RICH contains a sub-packet ID of 0, if the base station receives the frame an acknowledgement (ACK) is transmitted to the mobile station 120. If mobile station 120 receives the ACK it will transmit a new packet on the R-ESCH with a sub-packet ID of 0. If, however, the mobile station does

not receive the ACK it may retransmit the original packet and increment the sub-packet ID. This cycle continues until mobile station 120 receives an ACK from base station. Base station may analyze these sub-packet IDs (block 410) to determine the validity of the detected packet. If the sub-packet ID does not contradict what base station expects, a good frame may be declared (block 412). When the sub-packet ID does contradict what base station expects a bad packet may be declared. This may happen, for example, if base station previously sent an ACK to mobile station 120. Base station may expect the next sub-packet ID to be 0, if it receives a packet with a sub-packet ID other than 0 a bad frame can be declared. For a mobile station in soft handoff, where the mobile station communicates with multiple base stations, even when a base station did not previously send an ACK to the mobile station but receives a new packet with sub-packet ID equal to 0, the base station considers that the new packet does not contradict it's the base station's expectation, as the previous packet may be ACKed by other base stations.

[0048] In a similar manner, if base station detects the presence of a packet (block 404) and it is not a zero-rate packet (block 406) it may analyze the payload of the detected packet (block 410). For example, base station may be expecting two R-RICH packets corresponding to the same encoder packet on the R-ESCH to have the same payload. If these expectations are met (block 410) a good frame may be declared, however, if the payload of these packets contradicts base station's expectations a bad frame may be declared. A good frame may be declared if both the sub-packet ID and the payload size match the expectations of the base station.

[0049] In many embodiments, when the sub-packet ID or payload is not what base station expects (block 410) the information present on the R-ESCH is used to further evaluate the validity of the current R-RICH frame. If a non zero-rate packet is detected on the R-RICH (block 404) with a proper sub-packet ID and payload (block 410), the information (payload size and sub-packet ID) in this packet can be used to decode the corresponding information present on the R-ESCH (block 414). If the R-ESCH decodes incorrectly (block 416) this indicates that the information on the R-RICH and the corresponding R-ESCH may not be consistent and a bad frame may be declared (block 420). If, however, the R-ESCH is correctly decoded based on the information contained in the corresponding R-RICH packet (block 416) a good frame may be declared (block 418). Additionally in this case, one or more of the previous packets on the R-RICH may be declared bad based on the contradiction between the current good frame and the

incorrect expectations derived from information contained in one or more of the previous packets of the R-RICH (block 418).

[0050] Returning to the top of FIGURE 5, if the base station decodes an R-RICH packet to generate a likelihood (block 402), and the likelihood (L) of the most likely codeword (W) is less than some threshold level (L<Th), it may be determined that no packet is present on the R-RICH (block 404). If the base station was expecting a zero-rate packet on the R-RICH (block 430) a bad frame may be declared (block 432). Conversely, if no zero-rate packet was expected a good frame may be declared.

[0051] In many embodiments, if a packet was not detected (block 404) on the R-RICH and no zero-rate packet was expected (block 430), the corresponding R-ESCH may be used to help assess the validity of the frame. If the energy is strong enough on the R-ESCH (block 434), contravening the indications of the R-RICH, a bad frame may be declared (block 436). If, however, the energy level (block 434) and the R-RICH channel are congruous a good frame may be declared (block 438).

[0052] The various aspects and features of the present invention have been described above with regard to specific embodiments. As used herein, the terms "comprises," "comprising," or any other variations thereof, are intended to be interpreted as non-exclusively including the elements or limitations which follow those terms. Accordingly, a system, method, or other embodiment that comprises a set of elements is not limited to only those elements, and may include other elements not expressly listed or inherent to the claimed embodiment. Additionally, the steps of the disclosed methods are presented in no particular order and may be interchanged without departing from the scope of the claimed invention.

[0053] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0054] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of

hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0055] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0056] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0057] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic

principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[0058] What is claimed is: